Explanation of Plate I.

All about natural size.
No. 1. Two larvæ injected with plaster of Paris.
No. 2. Four specimens partly injected with gelatin.
No. 3. Several of the dried specimens as obtained from Indian woman.

SOME OBSERVATIONS ON THE RELATIONS OF ANTS AND LYCÆNID CATERPILLARS, AND A DESCRIPTION OF THE RELATIONAL ORGANS OF THE LATTER.

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(With Plates II and III.)

It has been known for many years that the larvæ of certain Lycænid butterflies are attended by ants. This attention is due to the excretion by the larva, from a slit on the tenth body segment, of a liquid agreeable to the ants. There is also, on the following or eleventh body segment, a pair of evaginable organs of relation (Plate II, Figs. 1 and 2). These organs have been found in a large number of species, and Wheeler (9) states that the larvæ of some sixty-five species are reported to be attended by ants. Certain species, such as *Lycæna sonorensis,* feed within the thick leaves or in the bud-clusters of the foodplant. It would be of interest to know whether these larvæ have the organs developed to any extent.

I have made observations on the behavior of ants toward the larvæ of *Lycæna fulla* (3) and of *L. pseudargiolus,* var. *piasus.* I have found the larvæ of the latter species very generally attended in the third and fourth instars by the ants *Tapinoma sessile* and *Prenolepis imparis,* and occasionally by *Cremastogaster* and *Camponotus* (?). I kept a number of the larvæ in the laboratory, placing each individual in a separate pill box, and putting with each one or two of the ants which I had found with them. By substituting a disk of glass for the cover of the box, I was able to use a binocular microscope in watching the ants and larvæ.

The typical performance, as I have observed it, is this: An ant, on

discovering a larva, at once proceeds to stroke its posterior segments with the antennæ. The ant also feels around over the surface of the larva with its palpi. Very soon the evaginable organs of the eleventh segment are thrust out, and the ant, in its explorations, invariably touches one or both of these with its antennæ, causing them to be withdrawn. The ant immediately becomes greatly excited and darts about over the larva and its foodplant, with its mandibles extended. After several seconds it quiets down, and returns to its quest for food. The ant may be thus disturbed several times before the slit on segment ten opens, and a sort of papilla is partially thrust out, bearing a drop of a clear, somewhat viscous liquid. This the ant eagerly laps up, stroking the larva with the antennæ meanwhile. My observations show that the larva of *L. piasus* emits a drop of this liquid about every fifteen minutes.

The majority of observers who have noticed the evaginable organs at all, state that they are apparently used as signals to the ants. Scudder (6), following Edwards (1), says, "the tentacles serve, when erected, as indications to the ant that the feast is ready." I have observed nothing that would lead me to this conclusion. The organs of my larvæ were usually partially protruded when the ants were not close at hand, and occasionally one or both would be shot out to the fullest extent, but I never saw the ants pay any attention to them at these times. Thomann (7) and others think that the organs diffuse some odor which attracts and fascinates the ants. I did not discover any cells in connection with the organs, as will be seen later, that might produce such an odor. Rayward (5) has noticed that ants attending the larvæ of *Lycæna corydon* were momentarily distracted by the appearance of the evaginable organs, just as I have described from my observations of *L. piasus*. My theory is that the sharp, fang-like projections on the setæ of the organs irritate the sensitive antennæ of the ant, and cause its excitement. It seems to be an attempt on the part of the larva to rid itself of the attentions of the ants when it is not able to satisfy their demands by giving up a drop of the liquid. The organs are never protruded when the liquid is emitted, nor while the ants are imbibing it. I was not able to bring about the protrusion of these organs by touching the larva or by any sort of rough handling. If the organs were already protruded, they were at once withdrawn, when the larva was touched.

I have, on various occasions, seen an ant touch the organs before they were entirely evaginated. They were at once withdrawn, the ant showing no signs of excitement. If it is a tactual irritation which distracts the ant, this failure to become excited on the part of the ant, when it touches the partially protruded organs, would be explained by the fact that the setæ occur only on and near the tip of the diverticulum, and would not yet be exposed. While watching the ants, I noticed that occasionally one of them touched the fully extended organs with its antennæ, without appearing to be affected thereby. One ant in particular was not thus stimulated during one of my observations. A half hour later, the same ant ran about wildly whenever its antennæ came in contact with the extended organs. I cannot explain this occasional insensibility of the ants.

The action of the organs of the larva seems to be a reflex caused by the stimulus of the ant's stroking the surface of the body. When this stimulus, which is evidently transmitted by the tactile hairs, is present, one of two things occurs. If the sac in the tenth segment is in a condition to exude a drop of liquid, it is everted, and the liquid is forced to the exterior. When this condition does not obtain, the organs on the eleventh segment are thrust out. The evagination of one or both of the organs, when there is no ant present, must be caused by the relaxing of the retractor muscle due to some other cause. I had one larva which had one of these organs continually thrust out, and rough handling or contact with an ant did not cause it to be withdrawn. Apparently the retractor muscle had lost its power of contraction.

I can offer nothing new in regard to the protection afforded the larvæ by the ants, except what I have already given (3) in respect to the larvæ of *L. fulla*. Here, the commonest parasite that I found was a Tachinid. I found the eggs of this on many larvæ in the first and second instars. The ants were not attracted to the larvæ until the latter had reached the third instar. I did rear a Braconid from one larva, and it is probable that there are other parasites. I have observed no parasites in rearing *L. piasus*. The external opening of the glands in these species is present in the second instar and the evaginable organs appear in the third instar.

The slit already mentioned occurs on the caudo-dorsal part of the tenth body segment (Fig. 1). It is about 0.5 mm. in length and

narrowly oval in shape. It opens into a shallow pit (Fig. 9) bordered by tubercles giving rise to hairs. These hairs (Fig. 7, *h*) are beset with rather long spicules, except basally, and probably serve to hold the drop of liquid in place after it has been exuded. As is shown in Fig. 8, *h*, when the sac is thrust out, their position is outside. In the center of the pit is a small, transverse opening through which the liquid is voided. Directly below this opening is a sac (Figs. 6 and 7, *l*), a simple invagination of the cuticula and of the hypodermis. This fact is shown in Fig. 8. It is this sac which appears as a papilla when the liquid is voided (Fig. 2, *p*), being everted by blood-pressure and retracted by two retractor muscles (Figs. 6 and 7, *r.m*), one attached to each side of the sac. The other ends of these muscles are attached to the body wall ventro-laterally. There are four glands supplying the liquid (Figs. 9 and 10). These are irregularly rounded, the anterior pair being the largest. Each is connected with the sac by means of a short duct. Sections (Figs. 6, 7 and 8) show how these glands open into the lumen (*l*) of the sac. The walls of the glands consist of hypodermal cells with their basement membrane (*b.m*), and are lined with a cuticular intima (*int*) traversed by pore canals for the passage of the secretion from the cells to the lumen. The cells lining the ducts appear to be much thicker than those of the glands, and rounded within. The intima is also somewhat more thickened here. The whole organ is very much like the organs possessed by various caterpillars of the Lepidopterous families *Notodontidæ* and *Liparidæ*, as described by Klemensiewicz (2). In these, however, the secretion is used in defense.

The evaginable organs are found on the eleventh body segment, each being posterior to the spiracle of the same side and nearer the lateral margin (Fig. 1, *e.t*). When these are retracted there is visible only a round or oval spot. When thrust out (Fig. 2, *e.t*), they have the appearance of whitish cylinders, bluntly rounded at the tips, and crowned with long, slender setæ (Fig. 4) arising from small tubercles. These setæ are studded with fang-like projections from the base to the tip. The organs are invaginations of the cuticula and of the hypodermis. Fig. 3, drawn from longitudinal sections of the retracted organ, shows the structure. Here, a thin layer of cuticula (*cut*) forms a lining to the retracted diverticulum. In live specimens the mouth of this is closed by folds of the cuticula. At the

bottom, the cuticula is modified into the tubercles or papillæ bearing the setæ (*s*). The hypodermal layer (*hyp*) is composed of smaller cells than in other parts of the body, except about the base of the organ. Here the cells are enlarged and somewhat pyriform. The function of these cells is to produce the setæ, and each cell tapers out through the cuticular layer to one of these (Fig. 4). No cells were discovered which might secrete an odor-producing liquid. Attached to a thickening of the cuticula at the base of the organ is a retractor muscle (*r.m*) which extends to the ventral wall of the larva, where it passes through the hypodermis and is attached to the cuticula (Fig. 5). It is probable that the body-tension is sufficient to evert the organs whenever the retractor muscles are relaxed, and a contraction of these draws them in again.

The skin of the larva is rather thickly set with spreading, stellate spines, from the center of each of which arises a toothed seta. These (Fig. 3, *t.h*) are hypodermal in origin, and without doubt are tactile in function. Viehmeyer (8) states that according to Thomann's theory these hairs serve to notify the caterpillars of the return of the ants. They are scattered over the whole surface of the body, but are most numerous dorsally, and perhaps a little more thickly distributed about the glandular opening.

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EXPLANATION OF PLATES II AND III.

Fig. 1. Larva of *Lycæna piasus*, dorsal view, showing position of external organs. (× 15.)

Fig. 2. Posterior part of same, lateral view, showing appearance of organs when protruded.

Fig. 3. Section through retracted evaginable organ; from vertical longitudinal sections of larva. (Camera lucida drawing, × 320.)

Fig. 4. A single seta of the evaginable organ, and its cell.

Fig. 5. Distal attachment of retractor muscle of evaginable organ to the body wall.

Fig. 6. Cross section of dorsal portion of larva through two of the glands; external opening not shown. (Camera lucida drawing, × 80.)

Fig. 7. Central portion of same, more enlarged. (× 220.)

Fig. 8. Section through opening of 10th segment, and sac, the latter everted; from vertical longitudinal sections of larva. (Camera lucida drawing, × 120.)

Fig. 9. Dorsal view of glands, the skin being removed except around the opening; from dissection. (Camera lucida drawing, × 90.)

Fig. 10. Ventral view of glands; from dissection. (Camera lucida drawing, × 90.)

b.m, basement membrane; *cut*, cuticula; *d.v*, dorsal vessel; *e.t*, evaginable organs; *f.b*, fat body; *gl*, gland; *h*, hairs about opening of sac; *hyp*, hypodermis; *int*, intima; *l*, lumen of sac; *l.m*, longitudinal muscles; *o*, opening of sac; *p*, sac protruded; *r.m*, retractor muscle; *s*, setæ; *spir*, spiracles; *t.h*, tactile hairs.

VENATIONAL VARIATION IN CLADURA (TIPULIDÆ DIPTERA).[1]

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(WITH PLATE IV.)

There have been three species referred to the genus *Cladura* Osten Sacken: *C. flavoferruginea* O. S. (1859), *C. indivisa* O. S. (1861), and a species which Loew called *fuscula* (1873).[2] Osten Sacken asserts,[3] however, that the latter is not a *Cladura* but possibly a

[1] Contribution from the Entomological Laboratory of Cornell University.

[2] Loew, H., Beschreibung Europäischer Dipteren, v. 3, pp. 64–67.

[3] Osten Sacken, C. R., Studies on Tipulidæ, Berl. Ent. Zeitsch., Bd. 30, 1886, Heft 2, pp. 205, 206.